

Cost of a Large Solid Scintillator Detector

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Starting Comments

- MINOS had many cost drivers
 - > Many things to work on for OA detector
 - > A number of things to change before we have a reoptimized detector
 - > MINOS had too much light (9 pe vs 4.7 pe)
- MINOS optimized for the scale
 - > Significantly more area changes the optimization between labor and automation
- LoDen (water or organics) makes a big difference in the amount of instrumentation (~3x)
 - > Steel design easy but silly if anything else feasible

Adiabatic Optimization

- 1) 5.4kt, 8m × 8m, 2.54cm Fe, M16
- 2) 20kt, 12m × 12m, 5mm Fe, M16 (for reference)
- 3) 20kt, 12m × 12m, 15cm particle board, M16
- 4) 20kt, 20m × 20m, 15cm PB, VLPC (high QE)
- 5) 20kt, 20m × 20m, 15cm PB, IIT
- 6) 20kt, 20m × 20m, 15cm H₂O, IIT (low QE)

#5 for strawman solid scintillator design

#6 for comparison with the liquid scintillator

Case 1: MINOS Far Detector (\$M)

> Scintillator strips	3.2	*Other Costs	
> Module parts/labor	5.3	> Coil, calibration	2.1
> Fiber	3.6	> Management	2.0
> PMTs/hardware	3.0	> Cavern/Outfitting	13.9
Scintillator subtotal	15.1	Grand total	46.9

> Channel electronics	4.5	Actives (no install/steel)
> Steel	4.5	= \$19.6M/26,600m ²
> Detector installation	4.8	= \$736/m ²
Far Detector total*	29.9	

Extrapolation to Fine Grain

- Move from "HCAL" to "ECAL"
 - > 2.5 cm sampling $\Rightarrow 0.5 \text{ cm } (\sim X_0/3)$
 - > 4.1 cm strips $\Rightarrow \text{OK?}$
 - > 5.4 kton $\Rightarrow 20 \text{ kton}$
- Too much light (2x)!
 - > Can do the physics with $\sim 4.7 \text{ pe}$
 - We have 9 pe
 - > We could save \$ at expense of light...
 - Reduce fiber diameter (light \propto diameter; \$ \propto area)
 - Reduce strip thickness (light \propto thickness; \$ \propto thick.)
 - Increase plane diameter ($\sim 6\text{m}$ atten. length)
 - N.B. atten length is longer the further along the fiber you go
 - A 12m square would still have enough light

Cage 2

HiDen Extrapolation

- Fine-grained
 - > 0.5 cm steel
- Make 20 kton
 - > 12m × 12m × 50m
- Other assumptions
 - > Assume Doug's 20% volume discount
 - > Make 2m-wide modules
- Vitals
 - > 490,000 m² (19x MINOS)
 - > Actives \$414/m²

Scintillator	\$47
Modules/labor	\$45
Fiber	\$53
PMTs	\$25
Electronics	\$33
Steel	\$18
<u>Installation</u>	<u>\$23</u>
Total	\$245M

Case 3

LoDen Solid Scintillator

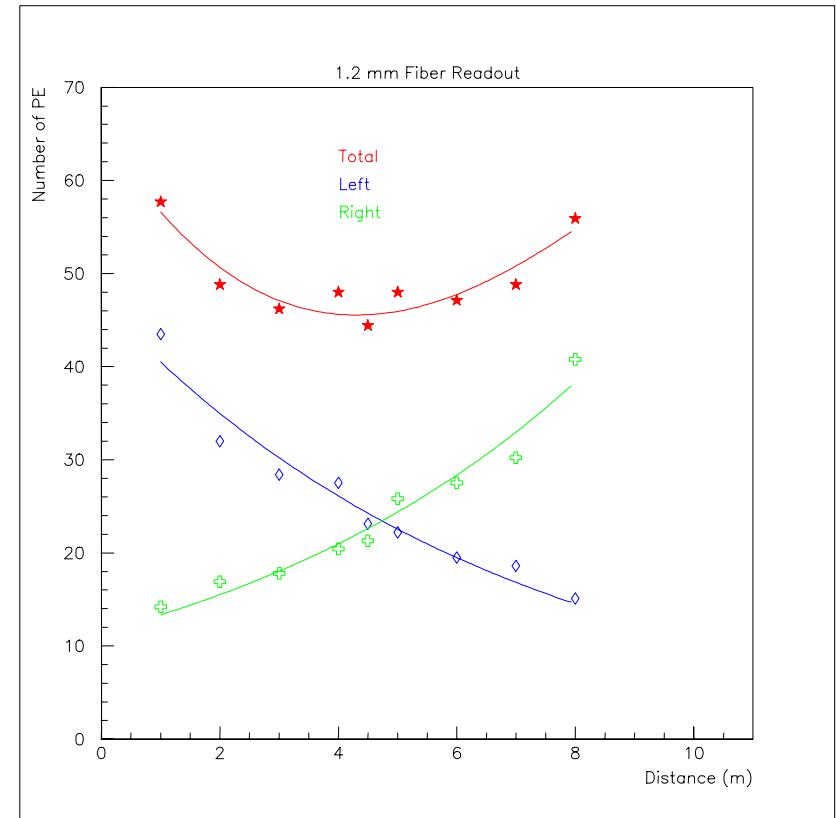
- Reduces area of instrumentation by about factor of 3
 - > 165,000m²
 - > About 6x MINOS
- Assume monolithic particle board absorber
 - > Self supporting
 - > Installation very similar to MINOS
 - > Can support the scintillator in same method at MINOS
 - > Construction industry good at making things with wood cheaply
 - Lots of cartage loaded screw guns instead of welding
 - > PB costs guessed from another speaker

<u>Scintillator</u>	\$16
<u>Modules/labor</u>	\$15
<u>Fiber</u>	\$18
<u>PMTs</u>	\$9
<u>Electronics</u>	\$11
<u>Part. Board</u>	\$6
<u>Installation</u>	\$8
<u>Total</u>	\$82M

Case 4

Example High QE Detector : VLPC

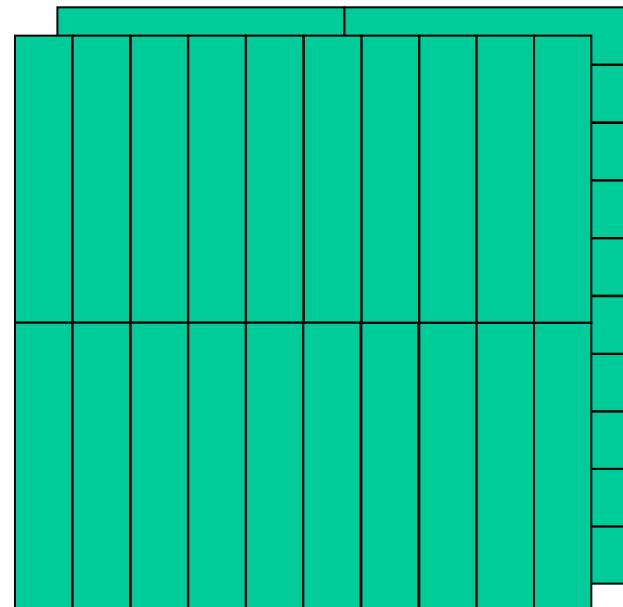
- Alan Bross used DØ VLPCs to look at MINOS strips
 - > Sees 48 pe per MIP
 - > Quotes DØ devices at \$50 per 1mm^2 pixel
 - > Can subdivide at cost of more electronics
- Can
 - > Thin scint to 5mm
 - > Thin the fiber 0.6mm
 - > Lengthen the strip to 20m
 - > ... still have enough light
- However
 - > You loose the 8X optical summing so Elec. costs up by 5x
 - > Get about the same cost but better fiducial fraction



Case 5

My Strawman

- Use 10m long strips with MINOS geometry
- 2 Single ended readout with 0.7mm fibers and mirrors
 - > 60% like MINOS ND
- Put modules end to end to make 20m square
 - > 15cm of particle board between layers
 - > Alternating views
 - > 410 planes
- IIT readout (\$3500/plane)
 - > 4 readout stations on each face to reduce clear fiber
 - > Need something like MINOS PMT box for IITs (~1k\$)



Case 5

Strawman Solid Scintillator Costs

- 6.2x MINOS area
- Active cost \$172/m²
(including all readout)
- IITs make this affordable

Scintillator	\$ 7.6
Modules/labor	\$11.2
Fiber	\$ 6.0
IITs	\$ 2.9
Electronics	\$ -
Absorber	\$ 6.0
<u>Installation</u>	<u>\$ 2.7</u>
Total	\$36.8M

Case 6

Adopt Ken's Geometry for Comparison

- 0.5mm fiber
- Double fiber
- Read each fiber on single end
- IITs
- Water cells for absorber
- Active cost \$192/m²
(including all readout)

Scintillator	\$15.8
Modules/labor	\$11.2
Fiber	\$ 3.1
IITs	\$ 1.4
Electronics	\$ -
Absorber	\$ 2.1
<u>Installation</u>	<u>\$ 2.7</u>
Total	\$36.4M

All Cases

	MINOS	HiDen MIN	LoDen MIN	HQE	IIT	Opt IIT
Scintillator	\$ 3.2	\$ 47.4	\$ 15.8	\$ 7.9	\$ 15.8	\$ 7.9
module parts/labor	\$ 5.3	\$ 45	\$ 15.0	\$ 9.0	\$ 11.2	\$ 11.2
Fiber	\$ 3.6	\$ 53	\$ 17.8	\$ 4.4	\$ 3.1	\$ 6.0
Photodetector	\$ 3.0	\$ 25	\$ 8.5	\$ 4.9	\$ 1.4	\$ 2.9
Electronics	\$ 4.5	\$ 33	\$ 11.4	\$ 52.3	\$ -	\$ -
Absorber	\$ 4.5	\$ 18	\$ 6.0	\$ 6.0	\$ 2.1	\$ 6.0
Installation	\$ 4.8	\$ 23	\$ 7.6	\$ 2.7	\$ 2.7	\$ 2.7
Total	\$ 28.9	\$ 245	\$ 82.0	\$ 87.2	\$ 36.4	\$ 36.8
Active total	\$ 19.6	\$ 204	\$ 68	\$ 79	\$ 31.5	\$ 28.0
\$/m^2 (active; w/ elec)	736	414	417	478	192	171

How to House?

- Do we need an overburden?
- If not building could be cheap
 - > e.g. At MSP Sun Country has Hanger with flexible sides
 - > Use free standing bridge crane
 - > Support walk ways off the the particle board
 - > Should look into costs
 - > Some minimal climate control and modular housing for the counting offices and DAQ